Yield advantage of hybrid rice induced by its higher control in tiller emergence

Tillering in favorable environments allows the plant to rapidly close the canopy and maximize light interception. As tillering dynamics respond to the level of resources available, tiller density at maturity is often independent of initial sowing density (Kataoka et al 1991). Tiller senescence during plant competition, however, may involve half of the emerged tillers. Lauer and Simmons (1988) reported few assimilate remobilization in barley from senescent tillers to growing tillers, and considered tiller senescence mostly as a wastage of assimilates. In sorghum, grain yield increased from 9 to 11 t ha^{-1} in high-density plots by removing all tillers of the plant as soon as they appeared, which, for most of them, became finally unproductive in the control plot (Lafarge et al 2002). In rice, tillering plays a key role since tiller number per plant as high as 40 and tiller senescence rate as high as 50% can be observed (Peng et al 1994). The opportunity to improve grain yield through an increase in tiller fertility rate was addressed in rice by comparing two genotypes, an improved inbred line and a hybrid with different tillering strategy but similar crop duration.

Rice plants in the field 36 days after sowing, grown in a wet-bed nursery and transplanted 14 days after sowing.

Materials and methods

Field experiments were conducted in the wet (WS) and dry season (DS) of 2003 in IRRI experimental farm, Los Baños, Philippines. IR72 (I1) and hybrid rice IR75217H (H1) were grown in nurseries at 3,000 seeds m^{-2}, either in wet-bed (WB) or seedling trays (ST), transplanted in four replications at 25 or 50 plants m^{-2} after 7 (WB07-25 and ST07-25), 14 (WB14-25), and 21 (WB21-25 and WB21-50) days after sowing (DAS).

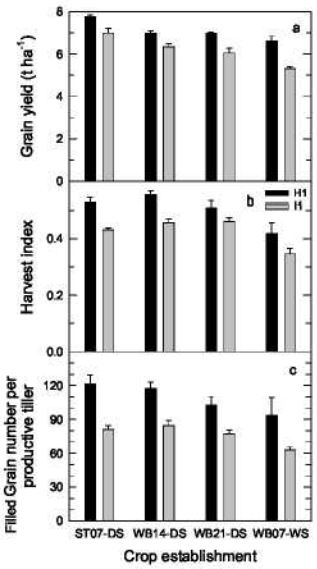

Fig. 1. Grain yield (a), harvest index (b), and grain number per productive tiller (c) for contrasted crop management schemes for hybrid rice and IR72.

Results

- Significantly higher grain yield by 1 t of H1 compared with I1, valid for contrasted growing conditions (Fig. 1a).
- No notable difference in the dynamics of leaf and stem dry weight per plant between H1 and I1 until maturity (Fig. 2a), and in tiller number per plant until 35 days after sowing (Fig. 2c). Higher panicle dry weight per plant at maturity for H1 (Fig. 2a).
- Higher leaf area index of H1 compared with that of I1 at 35 days after sowing (Fig. 2b, insert), even if it has similar value at 42 days. Higher LAI_{max}, 4.5 compared with 3.5, observed for I1 (Fig. 2b).
- Earlier cessation in tiller emergence per plant for H1, with difference in tiller dynamics notable from 35 days (mid-tillering), but close productive tiller number per plant, 14.1 for H1 against 15.8 for I1 at maturity (Fig. 2c).
  - Lower maximum tillering in H1, 20, against 28 in I1.
  - Higher fertility rate of tiller for H1, 69%, against 56% for I1.
- Higher stem and leaf dry weight per productive tiller for H1 over I1 from 42 days until mid-grain filling (Fig. 2d).
- More dry matter remobilization from stem to panicle for H1: higher decrease in stem dry weight from flowering to maturity (Fig. 2d) and higher harvest index (Fig. 1b).
- Higher panicle dry weight per productive tiller for H1 at maturity, close to 1 g higher, but with same leaf and stem dry weight (Fig. 2d).
  - Higher grain number per productive tiller for H1 (1000 grain dry weight was similar across both genotypes) (Fig. 1c).
- Same trend observed for the range of nursery management and for the wet season (data not shown).

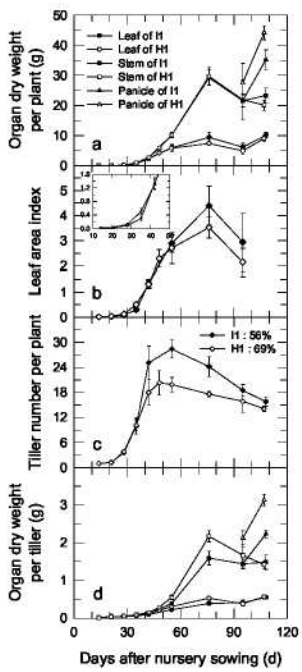

Fig. 2. Change, with days after nursery sowing, in organ dry weight per plant (a), leaf area index (b), tiller number per plant (c), and organ dry weight per productive tiller (d), for seedlings grown in WB14-25 during the dry season. In b, percentages indicate the rate of total tillers at maximum tillering that produced grain at maturity.

Conclusion

The higher efficiency in assimilate partitioning of hybrid rice compared with IR72 was the main reason for its observed advantage in grain yield. The ability of hybrid rice to produce greater leaf area per tiller at mid-tillering stage is one of the possible causes for an earlier cessation in tiller emergence. The newly gained assimilates were thereby mostly partitioned to existing tillers, while IR72 was still allocating part of the newly gained assimilates to the production of new, but future nonproductive, tillers. The more efficient control of tiller dynamics observed in hybrid rice increased tiller fertility rate and reduced assimilate wastage as productive tiller density at maturity was similar (also reported by Peng et al 1994). In addition, more remobilization of dry matter from the stems of hybrid rice is also assumed to have contributed to its greater grain yield. Hybrid rice then produced higher filled grain number and dry weight per panicle at maturity. These differences in growth strategy between both varieties was observed during the wet and dry seasons and for several crop managements schemes.

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